ASCOCHYTA PISI,—A DISEASE OF SEED PEAS.[1]

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During the season of 1904 and 1905, there was an exceptional blighting[2] of peas from *Ascochyta pisi* Lib. The disease was general throughout the state and occasioned loss especially where peas are grown in large areas for canning purposes.

My attention was first called to this trouble June 24, 1904, on French June field peas, which had been sown with oats as a forage crop. Most of the peas at this time, were about two feet high and just beginning to bloom. The lower leaves were, for the most part, dead. A few plants were wilting after several days of sunshine following continuous wet weather. Other stunted peas grew among these, some of which never attained a height greater than a few inches.

Appearance on stems, leaves, pods and seed.—A close examination of the plants showed that the stems had been attacked at many points, frequently as high as one and one-half feet from the ground, though most severely *near* the ground where the disease starts. In the beginning, dead areas were formed on the stem in the form of oval or elongated lesions. At a point, from the top of the ground to two or three inches above the ground, these lesions were so numerous and had spread so rapidly as to become continuous, leaving the stem encircled by a dead area. In some cases, the woody part of the stem was also dead, though the greater number of such plants still remained green above. This was due to the excessive amount of moisture in the soil and atmosphere previous to this time. On the leaves, were orbicular or oval dead spots, one-fourth to one cm. in diameter. These areas are darker at the circumference. Below, the leaves were badly spotted, causing them to die. In the greenhouse, the spotting of leaves failed to develop, though the attack at germination and at the base of the stem was more severe than out of doors. The dead areas at the base never extend much above the surface. Such plants as are not killed

1. Presented at the Cincinnati meeting, Ohio State Academy of Science.
2. The disease has been erroneously termed "Club root" by canners, since, on examining the roots for cause of dying, nodules common to members of the family Leguminosae, have been observed.

by the fungus by the time of flowering, develop pods in proportion to their vigor. The pods are badly attacked and exhibit spots quite similar to the ordinary anthracnose of the bean. In a case of *Ascocyhta pisi* on Egyptian-peas, Lochhead[3] describes the spots on pods to have "rings of black specks more or less concentric." No such appearance was found in connection with any of the peas examined. However, the Egyptian-pea belongs to a different genus from any host found by the writer to be affected with *Ascochyta pisi.*

Perhaps the most important thing in connection with the life history of the fungus, is, that it grows through the husk into the seed. Frequently, when the pod contains no seed, the mycelium will grow through, forming similar spots on both sides of the pod. When the mycelium passes into the seed, brown spots are formed on the surface. In the worst cases, half of the surface is frequently discolored and the seed adheres to the husk. These areas are much more striking on *green* peas such as the Market Garden than on the yellowish varieties as the Admiral. Peas affected with the mycelium of the fungus, can not always be told by an ordinary microscopic examination. A considerable amount of mycelium sometimes fails to color the pea and no spot is developed until the pea is exposed to considerable moisture for a short period.

The fungus.—The pycnidia of the fungus are formed on the dead areas of the stems, leaves, pods and seed and even on dead stems and branches where the effects of the fungus are not easily noticeable. They are ordinarily brown, have a circular opening and measure 125 to 160 μ in diameter. On the seed, they are formed on the outer surface, but frequently this is cracked away and fruit bodies occur below. Here they are often of a yellowish or amber color and occur in numbers from a few to several dozen and are sometimes so crowded as to form almost a solid mass for as much as five or six mm. in diameter.

The spores are oblong, usually 2-celled and slightly constricted at the septum. Those of the field-pea (French June), measured 12 to 16 x 4 to 6 μ. One measurement of spores on pea seed showed them to be 8 to 11 x 5 to 7 μ and practically all continuous; while those on a specimen of Market Garden seed, were 10 to 20 x 3 to 5 μ and a few, even, were 2-septate, measuring as much as 23 μ long. Lack of maturity was the chief cause of the continuous spores, though some of these never become septate. Lochhead[4] reports only a few 2-celled spores found in some material of Egyptian-peas affected with *Ascochyta pisi. Ascochyta pisicola* (Berk.) Sacc., which is perhaps identical with

3. Ont. Agr. Coll. and Exp. Farm. An. Rep. 1903, pp. 17–33, figs. 13.
4. Lochhead, l. c., p. 27.

A. pisi Lib., is described as being either 1-septate or 1-celled. *A. Bolthauseri* Sacc.,[5] found on the leaves of bean, is often 2-septate.

Cultures.—Halsted[6] who was first (so far as the writer is able to learn) to note and to figure the pea seed affected with *Ascochyta pisi*, states that seed "apparently healthy when placed in the ground, soon show patches and spots of a dark color, which are also the spore bearing places of Ascochyta."

Krueger[7] noticed the presence of the fungus by soaking seed for twenty-four hours in water, when dirty spots would appear. When left for forty-eight to seventy-two hours, the mycelium grew out into the water forming a white mass of radiating threads similar to those of *Saprolegnia*. All these results of Halsted and Krueger were verified.

If one places such diseased peas in a seed germinator for several days, a heavy coat of white mould will be formed about them. On removing these to a covered dish where less moisture is present, numerous reddish-brown pycnidia are formed all through and over this white fluffy mass of mycelium. (Of course this mycelium must not be confused with a similar growth of some such fungus as Fusarium which often contaminates peas and beans, when not kept dry,—especially just before harvesting.) Peas which failed to germinate in the ground, were removed, with the result, that they too, soo developed pycnidia on the mycelium surrounding them. The germination of such seeds is very poor. Krueger found the germination of very badly affected seed to be 20%. In similar experiments conducted by the writer the germination was only 6%. Such peas seldom reach maturity when they do germinate, as the fungus affects the base of the young plant. Hiltner[8] records the sudden dying of peas from such attacks at the base of the stem. The fungus was carried over to the young plants by the seed, a fact determined through experiments by Jarins[9]. The result of these early attacks by the fungus, is all sizes and vigor of plants. Plants of equal age, range in height from two inches to four feet. In the struggle between the fungus and host, the latter may not noticeably increase in size for a long period, or it may succumb at any time. Young plants six inches high, affected with the fungus, were planted against healthy ones of the same size, with the result, that the latter became diseased in a few days. Later, fruit bodies formed abundantly.

5. Bolthauser–Amrisweil. Blattflecken der Bohne. Zeit. f. Pflanzenkr., p. 135.

6. Halsted, Some Fungous Diseases of the Pea. N. J. Rept., pp. 357–362. 1893.

7. Krueger, Ungewoenliches Auftreten von Ascochyta pisi Lib. on Erbsenpflanzen. Centl. f. Bak. u. Par. 2, I., p, 620. 1895.

8. Hiltner, Erbsenmuedigkeit. Sachs. landw. Zeitung., 1894, No. 18.

9. Jarins, Ascochyta pisi bei parasitischer und saprophyter Ernahrung. Bibl. Bot., Heft 34, 1896, c. tab.

Seed treatment.—Many experiments in seed treatment by immersion were carried on during 1904 and 1905, but all proved unsuccessful. The presence of the mycelium and spores *within* the seed, has, so far, rendered treatment impossible, since any solution strong enough to kill the fungus, also kills the pea germ. In fact, the fungus is the less susceptible of the two. Still it was hoped to kill such spores as might be merely adhering to the outer seed coat of the peas and thereby increase the per cent. of germination. The chief chemicals used were formalin and mercuric chloride. These were used in several strengths and for various lengths of time. The seed was then planted in soil (in the greenhouse) or put into a seed germinator. The results, for the most part, were not only unsuccessful, but negative. Liquid treatment, especially when the seed was immersed for a considerable period, seems to increase the bacterial rot[10] which is also responsible for the failure of some of the seeds to germinate. Direct immersion in hot water as well as immersing in hot water after soaking, was tried by Krueger, with the result that the vitality of the seed was injured, while the fungus was not. Dry heat was also applied with similar results. Though Krueger found seed treatment with Bordeaux mixture ineffective, experiments carried on by the writer during the present season, showed a slight increase in germination over check plots, when seed was soaked for an hour in water rolled in Bordeaux dust and immediately planted. The following table gives the average results obtained by this treatment. The figures show the number of grams produced from one foot of row; also the gain or loss in per cent. The peas were drilled in rows three feet apart and not sprayed:

TABLE I.

Variety.	Early Planting.			Late Planting.		
	Tr.	Untr.	%G orL	Tr.	Untr.	%G orL
Market garden	21.9	21.6	+ 1.4	4.9	4.3	+14.0
Admiral	29.0	27.8	+ 4.3	4.2	3.4	+23.5
Telephone ..	14.8	11.5	+28.7	*...	....	....
French June .	21.6	21.4	+ .9	....	....	....

* No late planting.

The result of tying up vines, of spraying with Bordeaux and of omitting the last spraying, is shown in the following table.

The per cent. of gain or loss of sprayed over unsprayed, is computed for the early planting only, as the late crop of unsprayed was planted somewhat later than late planting where spraying was done. Moreover, the almost complete failure was due, in large part, to powdery mildew, which failed to develop in

10. Halsted, Failure of Pea Seed to Grow. N. J. Rept., 1893, pp. 359–362.

the least on the sprayed crop. Though the sprayed rows and those tied up, produced, in general, more than the checks, the gain was scarcely sufficient to warrant such treatment merely to increase the quantity of peas. The object, however, of such treatment, is more for the purpose of growing uninfected seed peas in order that so great loss may not be experienced from a poor stand and to start a crop free from the disease. This, on soil free from the disease, ought to improve the situation. Although a test of the per cent. of germination of the 1905 seed has not yet been completed, the seed from tied up and from sprayed peas, was much freer from the fungus than that from the check lots. Notwithstanding the great care in spraying, the results are certainly not what they would be under more favorable conditions of weather. The almost daily rains rendered it impossible to keep a coat of Bordeaux on the plants.

TABLE II.

VARIETY.	SPRAYED.								UNSPRAYED		% G. or L. in sp. in early planting.
	Tied up.	Not t. up	% G. or L.	Sprayed late.	Not sp. late.	% G. or L.	Not t. up nor sp. l.	% G. or L.	Early pl.	Late pl.	
French June	24.2	25.9	‡ 6.6	12.6	9.5	†32.6	14.7	†29.1	21.4	*....	†21.0
Market Garden.....	26.3	20.3	†29.5	9.6	8.2	†17.1	19 9	‡17.2	21.6	4.5	‡6 0

* No late planting made. † Gain. ‡ Loss.

The early training up of peas seems to be an important factor in securing healthy seed peas, since the fungus makes its first attacks near the ground and gradually works itself up the stem, branches and leaves. The height (on the plant) to which the fungus will attain in a given time, is therefore dependent, to a certain extent, upon how much of the vine lies upon the ground.

Hosts.—All the varieties of the common pea examined during the past year, were found to be affected with *Ascochyta*, though some much more seriously than others.

The following is a list of those carefully examined:

French June.....Very badly.
Market Garden..... " "
Admiral.....Badly.
Dwarf Telephone....Very badly.
Telephone .....Badly.
Prosperity.....Badly.
American Wonder ...Very badly.
Advancer.....Badly.
Alaska.....Slightly.

So far as the writer is able to learn, no investigations have been made as to the susceptibility of varieties. Aside from the genus *Pisum* however, it has been found to attack *Medicago sativum*[11], *Cicer arietinum*,[12] *Phaseolus vulgaris*[13] and *Vicia vil-*

11. Lagerheim, Bihang till K. Svenska Vet.—Akad. Handlingar. 1898. Bd. XXIV Afd. III, No. 4, 21p.
12. Rostrup, "Tidskrift for Landrugets Planteavl" V, No. 14, Kjobenhavn 1898.
13. Carruthers, Jour. Roy. Agr. Soc. Eng. Ser. 10 (1899) pts. 4, 678–688.

losa.[14] A critical examination of the species of *Leguminosae* grown at the station in 1904 and 1905, showed all of these to be free. Following are the results from the various *Leguminosae* grown on the Station variety plots in 1904 and 1905:

Host.	Examined July 22, 1904.	Examined July 28, 1905.
Hairy Vetch	Free	Free.
Spring Vetch	Slightly on leaves	"
White Lupine	Free	*
Lentils	"	*
Grass Peas	"	Free.
French June Peas	Very bad	Very bad.
Scotch Gray Peas	Slightly on leaves	On leaves and stems
Velvet Beans	Free	*
Horse Beans	"	Free.
Medium Green Soy Beans	"	*
Mammoth Yellow Soy Beans	"	*
Beggar Weed	*	Free.
Yellow Lupine	*	"
Flat Peas	*	"
Alfalfa	Free	"
Egyptian Peas	"	"
Russian Blue Peas	"	"

No planting.*

Climate certainly determines largely the seriousness of attacks by this fungus. For example, Lochhead[15] describes a serious outbreak on Egyptian-peas in Ontario in 1903. Yet, while we have experienced an exceptional attack by the fungus during 1904 and 1905, Egyptian-peas have proved to be entirely free of the disease. Excessive moisture during these two years, is doubtless the chief factor in this outbreak. Added to this, is the continual growing of peas on the same ground. When peas have been planted on the same soil for two or more successive years, the loss may be considerable, even in ordinary seasons. Two years rotation in other crops, relieves the land of the trouble for the time at least, showing that the fungus lives over in the soil or compost as well as in seed peas.

Previous outbreaks have been reported. Krueger[16] states that in one place, the cultivated field crop was a complete failure in 1894. Combes[17] reports it as attacking pea stems so seriously as to cause a wilting of the tops, in 1879.

14. Ducomet, Prog. Agr. et Vit. (EdL'est) 22 (1901) No. 34, pp. 225–233.
15. Lochhead, l. c., p. 26.
16. Krueger, l. c., p. 621.
17. Combes, Crittogamia agraria, p. 473.

Botanical Laboratory, Ohio Agricultural Experiment Station,
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